The sidereal and solar day

Study time: 2 hours

Summary

In this observational activity you will measure the difference in length of time between the sidereal day, as kept by the stars, and the mean solar day, as kept by an ordinary watch, by observing the civil time at which a star crosses a fixed direction in your sky on different dates.

The background to this activity is described in Section 1.3.1 of the *Observational activities* booklet. The video sequence 'Preparing for observing' also provides help, and you should watch it before you take any measurements.

The study time indicates how long you will need for the observing session(s) and includes preparation and note taking; the observations themselves should take less time. Data analysis and writing up require *additional* time after the observing session.

Learning outcomes

The learning outcomes for the observational activities are grouped together at the front of the *Observational activities* booklet.

Preparation

You should do the activity 'In and around Orion' before you do this one.

You need to choose a star and a reference direction. In principle, *any* star and *any* reference direction will do, but there are some practical considerations. Consider the star. It needs to be bright and easy to find. Also, a star nearer the celestial equator will move across the sky through a greater arc in a given time than a star away from the equator, thus allowing better precision in the timing. Therefore, choose a bright star not very far from the celestial equator. For February or March evening observations, Betelgeuse and Rigel in Orion are suitable. For other dates and times you will have to use your planisphere to select a suitable star.

The reference direction is set by a fixed observing position and a fixed terrestrial object located between this position and the star. For the object, some kind of edge is strongly recommended. Avoid edges that the star will cross at a grazing angle – the precision of the timing would then be very poor. A vertical edge of a building is a very suitable object, and it should be at least 20 metres away to ensure adequate measurement precision. For example, the chimney in Figure 1 (*overleaf*) is a very suitable object. (The discussion here of the choice of reference direction assumes that the observer is well away from the Earth's Equator, that is the observer is at a latitude where stars near the celestial equator do not rise very high in the sky.) In this particular case, the observing position is fixed by the observer leaning the head against a particular spot on a wall, and making all observations with the same eye. The star is then seen to pass behind the chimney at intervals of one sidereal day.

For a given star and given date, the civil time at which the star is in the reference direction depends on your particular choice of reference direction. It is advantageous if this direction is within 30 degrees or so of due south, because the star is then not far from its highest altitude, and will be less dimmed by atmospheric extinction and less likely to be hidden by terrestrial objects.

Finally, it is convenient to see the star approach the edge, rather than emerge from behind it, and so it is better to use the eastern edge of an object rather than the western edge.

Whatever your choices of star, edge and observing position, do ensure that you record your choices in your activity notebook – you will need to make all timings from the same observing position, using the same star and the same edge.

When you go to your observing site to do this activity, you will need to take with you

- these activity notes
- a torch (flashlight)
- a watch, set to the nearest few seconds (using the telephone, or a radio time signal)
- your activity notebook, plus something to write with.

Figure 1 The chosen star approaches the reference edge (the chimney stack).

Making measurements

You need to measure the time at which the star crosses the edge on at least three nights (although four or five nights would be far better) spread over two to five weeks. Use your planisphere to help you decide roughly when you should arrive on site: if daylight saving time is in force (in the UK after late March), then remember to subtract an hour to obtain the time shown on the planisphere.

At your observing site, place your head in as repeatable a position as possible. In Figure 1 this is achieved by leaning against a particular spot on the wall. Also, always observe the star with one eye, the same eye each time – your eyes are about 0.07 m apart, which corresponds to an angle of about 0.2° at 20 m, which can give a timing error of nearly a minute.

You will have plenty of time to observe the star's approach to the edge. Even for a star near the celestial equator, as the Earth rotates, the star will appear to move

west at only about 1° in 4 minutes. However, such slow progression does mean that, without optical aid, the time at which the star crosses the edge cannot be measured very precisely. The main problem is slight movements of the head. These will cause the star to bobble in and out of view: the closer the edge, the larger the apparent random stellar motions, and the longer for which the bobbling carries on. The time to be recorded in your activity notebook is that at which the star is in view roughly half the time. You must also record your estimated uncertainty in this time. A large uncertainty means that, if you carry out observations on successive nights, it might be difficult to discern any difference in the crossing times. However, by spreading at least three observations over at least two weeks, you will be able to obtain a reasonable value for the difference in length between the sidereal day and the mean solar day.

Data analysis

To obtain the difference in length between the sidereal and solar days, and its uncertainty, if you have at least three observations, you should follow the graphical method in Section 3.2 of the *Observational activities* booklet. If, unfortunately, you have only two observations, a simple calculation will suffice.

You may wish to use your value for the difference in length of day to predict the crossing times in the days to come, and then you could check your predictions.